NOTES ON THE SERPENTINOUS ROCKS OF ESSEX COUNTY, NEW YORK; FROM AQUEDUCT SHAFT 26, NEW YORK CITY; AND FROM NEAR EASTON, PENNSYLVANIA.

BY

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A.—ESSEX COUNTY, NEW YORK.

That the Serpentine of the ophiolite of Thurman, Warren County, New York, was a secondary product after a lime magnesian pyroxene has been stated by the author in a previous paper.* Since that paper was written he has, through the kindness of Prof. J. C. Smock of the State Museum at Albany, had an opportunity for examining similar material from Bolton and Warrensburgh, in Warren County, and from Amity, in Orange County. In all of these the serpentine is plainly of like origin.† It was also stated in the paper mentioned that a part at least of the Essex County serpentine was of like metasomatic origin, but that a considerable portion was apparently after a mineral the exact nature of which had not been determined. Further investigation has not completely solved the problem, but as the matter must be dropped here for the present it is deemed best to put on record such results as have thus far been obtained. As is well known the Essex County ophiolite is the primary limestone of Emmons, and which it will be remembered he considered to be of plutonic origin.‡

Concerning the composition of the rock this writer says:

> This range of limestone is distinguished throughout, so far as I am acquainted with it, for its compound character, being combined or mixed in several proportions with serpentine. In some parts of the rock the limestone and serpentine are in about equal proportions; in other instances the limestone predominates, the serpentine gradually disappearing, till only here and there a small portion is discernable, when

* On the Ophiolite of Thurman, Warren County, New York, with remarks on the Eozoon Canadense. By George P. Merrill, Am. Jour. Sci., XXXVII, March, 1889, p. 189.

† On account of the known occurrence of chondrodite in the limestone of Orange County it was thought that a portion at least of the serpentine of this locality might result from alteration of this mineral. None of the sections at hand show this to be the case. The altering mineral is in all cases colorless, non-pleochroic, with well developed prismatic cleavage, and is insoluble in acids. Chondrodite, on the other hand, is pleochroic in yellowish colors and shows only very imperfect cleavages, besides gelatinizing when treated with hydrochloric acid.

‡ Nat. Hist. of New York: Part IV, Geology, p. 228.

the limestone becomes a nearly pure rock, or free from intermixture with this substance. Whenever these two substances are commingled in the same mass, it is more free from siliceous minerals either in the form of quartz, pyroxene, or scapolite. It is difficult to describe the rock in a few words as it occurs at Port Henry. It is pure limestone near the furnace, quite coarse and crystalline. The steep rock west of the public house is a mixture of yellowish serpentine and primary limestone; * * * near the dwelling of Mr. Foote, is a mixture of the same materials; the serpentine is darker and the contrast between the limestone and serpentine is greater. * * * In the same bed, in addition to the mixture already mentioned, I found those of coccolite and pyroxene in crystals, blood-red mica or mica which transmits a blood-red light, hornblende, and limestone, etc. In the midst of the bed, half a mile from the lake (Champlain), is an extensive one of calcareous spar. * * * It contains a great abundance of graphite, etc.

The typical ophiolite as put upon the market consists of a quite even granular admixture of serpentine, calcite, and dolomite in particles from one-eighth to one-fourth of an inch in diameter, interspersed with small scales of phlogopite, occasionally graphite, and more abundant pyrrhotite granules. As noted by Emmons, however, the texture is variable, and, as seen by the writer at the now abandoned quarries near the village of Port Henry, the frequent occurrence of large blotches of yellow and greenish serpentine, or serpentine and white pyroxene, in sizes from an inch to a foot or more in diameter, proved a serious drawback to the production of marketable material. From the abandoned quarry of the "Ophite Marble Company," and other openings in the vicinity, it is easy to obtain masses of the serpentine showing pyroxenic nuclei, and all stages of the alteration are readily traced. At the Ophite quarry was selected what seemed a typical sample, (70085) and from it was picked out the unaltered pyroxene and the secondary yellowish green serpentine. These, submitted to Mr. Catlett, of the U. S. Geological Survey, for analysis, yielded as follows:

	Pyroxene.	Serpentine.
SiO_2	55.36	42.17
Al_2O_3	.22	.30
Fe_2O_3	.22	1.57
FeO	.57	.64
MgO	19.53	41.33
CaO	24.48	None.
NiO	None.	None.
Cr_2O_3	None.	None.
MnO	Trace.	Trace.
H_2O	.....	13.72
	100.34	99.73

The pyroxene is therefore a very pure lime, magnesian variety, of the formula $CaMgSi_2O_6$, and its conversion into serpentine consists, as in the other cases described, in the assumption of water and giving up its lime, which crystallizes out in the form of calcite. The resultant serpentine is also of exceptional purity. The origin of the large masses of the yellowish serpentine is thus readily accounted for. It is to be noted, however, that the serpentine occurring in small particles scattered evenly throughout the granular portion of the rock is of

darker color, and so far as observed never showed under the microscope traces of residual pyroxene. Wherever, too, this darker variety of serpentine occurred in patches of any considerable size it was observed that it frequently contained inclosures of graphite scales. For the study of this variety of the rocks, material was selected from the quarry of Mr. J. E. Reed, some miles west of Port Henry. From this opening was selected four series of specimens, characteristic of the rocks as there occurring. These were (1) the merchantable ophiolite, a granular rock consisting apparently of about equal proportions of snow-white calcite and dark green serpentine (70082); (2) a similar textured rock, but of more uniform green color, the serpentine and calcite being less distinctly differentiated, and the calcite being moreover of a clear glassy appearance, and for this reason less notable; (3) masses from an inch to a foot or more in diameter, consisting mainly of deep though dull green serpentine, and often carrying large scales of graphite (70083); and (4) samples of the same shape and mode of occurrence, but consisting of a central portion or nucleus of coarse massive calcites and graphite scales, surrounded by a ring or zone of varying thickness of the dull green serpentine (70084). The last three forms occur sporadically throughout the beds, and as their presence is objectionable in the quarried blocks they are often the cause of considerable waste.

Sections from the two first-mentioned varieties showed the rock to consist essentially of calcite, serpentine, and dolomite. Rough determinations of the relative proportions of the various constituents were made by dissolving out from weighed portions of the pulverized rocks the calcite by acetic acid, the dolomite by cold hydrochloric acid, and in each case weighing the residues. Calculations from these results showed No. 1, the typical ophiolite, to consist of 52 per cent. calcite, 15 per cent. dolomite, and 33 per cent. serpentine; the second variety yielded, under like treatment, calcite 72 per cent., dolomite 2 per cent., and serpentine 26 per cent. An analysis of the dark serpentine out of the typical ophiolite (70082) from this quarry by Mr. Catlett yielded results as follows:

SiO_2	39.96
Al_2O_3	1.07
Fe_2O_3	3.53
FeO	3.85
MgO	37.61
NiO	none.
Cr_2O_3	none.
MnO	trace.
H_2	13.65
	99.67

This material it should be noted was separated out by specific gravity and subsequent treatment with acetic acid. Under the microscope the powder was of a dirty dull green color, opaque, and showed when the stage was revolved between crossed nicols a somewhat fibrous or

felty structure, more like sundry chloritic decomposition products as seen in eruptive rocks than like pure serpentine.

In the thin sections this variety of the rock furnishes no clew whatever to the origin of the serpentinous material. Sections of the second variety show, however, the rock to have consisted mainly of calcite and dolomite, and that the serpentine is a subsequent injection, replacing wholly or in part the calcite. Sections are readily obtainable showing the calcite granules, with only narrow and irregular veins of the serpentinous matter traversing them, through all gradations to complete replacement. It was at first thought that these granules might be dolomitic and actually undergoing alteration into serpentine, but chemical and microscopic tests showed them to be nearly pure calcite. The third and fourth varieties mentioned above were likewise found to consist of calcite (the coarsely crystalline variety mentioned by Emmons), replaced wholly or in part by the serpentinous matter. Samples were collected, and are now installed in the Museum collections, showing these masses of graphite-bearing calcite in all stages of replacement, from the formation of a ring of serpentinous material around the outer portion (70084) through varieties stained greenish throughout but still effervescing when treated with dilute hydrochloric acid, to compact masses of dark dull green serpentine, still at times showing traces of the calcite cleavage, and carrying as before scales of embedded graphite (70083).

The writer will not attempt to fully explain the source of this dark colored aluminous serpentine, which occurs as a true replacement rather than as a metasomatic product. If, as was first supposed, it too was derived from the colorless pyroxene, it is difficult to account for the large increase (6.03 per cent.) of iron oxides and alumina. It seems best to drop the matter here for the present rather than resort to speculations, which may not be borne out by future field observations.

Thanks are due Mr. S. E. Foote, of Port Henry, but for whose generosity in giving not only his own time, but also furnishing his private conveyance, it would have been impossible in the time at command to obtain for the Museum the full set of duplicate material, the collection of which was the main object of my visit.

B.—AQUEDUCT SHAFT 26, NEW YORK CITY.

This serpentine occurs in embedded masses in a coarsely crystalline white granular dolomite. It plainly originates through the hydration of a white monoclinic pyroxene, showing under the microscope nearly rectangular prismatic cleavages, and giving extinction angles as high as 44°. The alteration is accompanied with the formation of abundant secondary calcite. The serpentinous matter itself varies from nearly white or colorless to light greenish, or occasionally nearly black; the green color is never very pronounced. The hardness of the material is a trifle under 4 of Dana's scale, being softer than the Bowenite of

Smithfield, Rhode Island, which it at times resembles. Under the microscope the serpentine shows a platy, almost fibrous structure, the plates in each case lying approximately parallel with the vertical axes of the crystals from which they were derived. These plates do not extinguish simultaneously, but the alternate bands become in a general way light and dark as the stage is revolved between crossed nicols. The dark cloud, however, sweeps over in so indefinite a manner that nothing like extinction angles are obtainable. An analysis of the serpentine matter (70350) by Mr. Catlett yielded results as below:

SiO_2	39.92
Al_2O_3	.08
Fe_2O_3	.50
MgO	42.52
CO_2	1.64
CaO	.90
Moisture (at 105°)	1.36
Ignition	13.26
	100.18

For the material examined from this locality the Museum is indebted to Mr. George F. Kunz.

C.—OLD WOLF QUARRY, CHESTNUT HILL, NEAR EASTON, PENNSYLVANIA.

This serpentine, as is well known to American collectors, is of a light oil green or yellowish color, closely resembling that of Montville, New Jersey. As noted in the reports of the Pennsylvania Survey*, it occurs associated with calcite, gray limestone, asbestus and tremolite. The pure varieties, such as find their way into the cabinets of collectors (70125), are not obtainable in masses of any size, but occur in seams or sporadically scattered throughout a massive tremolite rock which is here quarried, and, after pulverization, used as a filler in paper manufacture. A beautiful bright yellowish green vermiculite (?) also occurs here. This will be described in another paper.

The association of the serpentine with the white tremolite rock is such as to suggest a genetic relationship. Indeed, it is possible in the quarry opening to trace the gradual passage, often within the distance of a few inches, of the pure white tremolite rock into a mixed rock composed mainly of serpentine, tremolite, and calcite (specimens 70114, 70115, 70119, 70122, 70123). Thin sections of the fresh tremolite (70122) rock show a compact aggregate of white non-pleochroic, somewhat fibrous crystals, with the cleavage of hornblende and giving extinctions on clinopinacoidal sections running as high as 20°. As serpentinization has set in the tremolite crystals are broken up into fibrous aggregates traversed by irregular canals of the serpentinous matter, the direction of which has been but little controlled by the cleavage lines

* Rep. D^3, Second Geol. Survey of Pa., p. 79.

of the mineral. The method of alteration corresponds closely to that described by L. P. Gratacap as having taken place in the amphibolic rocks lying between Fifty-fifth and Sixtieth street, New York city.*

An analysis of the tremolite, separated out from the fresh pulverized rock (70122), yielded Mr. Eakins as follows:

	Per cent.	Ratio.
SiO_2	58.27	.97
Al_2O_3	.33	.....
Fe_2O_3	trace	.....
MnO	.08	
CaO	11.90	
MgO	25.93	.965
K_2O	.42	
Na_2O	1.25	
H_2O	1.22	

As above noted, the pure compact serpentine occurs only in veins associated with snow-white calcite. The main mass of the rock is of a dull greenish hue and consists of a mixture of serpentine, secondary calcite, vermiculite, and remnant shreds of tremolite.

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*Am. Jour. Sci., 3, XXXIII, 1887, p. 374.